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Effects of Automatic Take-Off Settings on Individual Cow Milking Duration and Milk Production

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Abstract

A switchback study design was used in five commercial dairy herds to study the effect of altering the end of milking flow settings of automatic cluster removers (ACRs) on average duration of unit attachment and milk yield. The end of milking flow settings were alternated between 1.1 and 1.4 lbs/min in one herd and between 1.6 and 1.8 lbs/min in the other herds. Parlor data were captured at 329 separate milking sessions (range 39 to 92 per herd), representing 239,393 individual cow milkings.

Increasing the ACR end of milking setting decreased the duration with no harmful effect on the average pounds of milk harvested per cow. Average duration was significantly reduced in all but one of the five herds, with the estimated reduction ranging between 10.2 and 15.6 seconds per cow in the four responding herds. Milk yield per cow increased slightly in two herds and was not reduced in the other three herds.

Increasing the ACR end of milking flow rate had a positive effect on variables affecting individual cow milking performance. Altering ACR settings represents an important opportunity to improve milking efficiency and parlor performance in commercial dairy herds.

Introduction

Milking efficiency is a limiting constraint to profitability on many dairies. While there are many factors influencing overall milking efficiency and parlor performance, individual cow production and length of unit attachment (duration) are very important.

One variable affecting length of duration is the end of milking flow setting for the automatic cluster removers (ACR). The operating principle for ACRs is to detach the unit once milk flow has dropped below a preset level. (There may be an additional adjustment, usually called "delay time". In this study the delay was set to 1 sec to eliminate it as a variable.) Factory defaults for the model of ACRs used in this study were a flow rate of 0.7 lbs/min and a delay of 13 seconds.[1]

Field experience in commercial dairies suggests that deviating from the factory default settings can decrease unit duration while maintaining the quality and volume of milk harvested.[12, 13] In addition to the field data, there is one report from a research herd. In a 36-wk clinical trial of 71 first lactation heifers and a 12-wk clinical trial of 64 older cows, changing the ACR minimum flow level from 200 to 400 g/min (from 0.44 to 0.88 lb/min) resulted in reducing machine on-time by 0.5 min with no reduction in milk yield.[11]

The specific intervention studied in the current study was to evaluate the effects of raising ACR end of milking flow rate settings on measures influencing milking efficiency: average milking duration (min/cow) and milk yield per cow (lbs/cow). Therefore, the goal of this study was to determine if duration could be reduced without sacrificing milk production.

Materials and Methods

***Data Collection*·** A cooperative project was conducted between Dairy Equipment Company (DEC), Valley Agricultural Software (VAS), and the University of Minnesota. The project's primary goal was to provide dairymen with reliable, relevant information to improve parlor management. This goal was to be achieved by improving the accuracy of the automatic identification system, increasing the resolution of existing data, and capturing additional data. The central components of this project were:

- Bou-Matic Provantage milk meters, automatic cluster removers, electronic cow identification and 2045/2050 parlor controllers (DEC) (Madison, WI)
- DairyCOMP305 herd management software (VAS) (Visalia, CA).

The system was implemented on five larger commercial dairies in the Midwest. Herd sizes ranged between approximately 460 and 1300 milking cows. The herds were well managed with excellent equipment maintenance and good udder preparation procedures.

A field study was conducted during January 1999. Data from the five systems were collected at each milking. The treatment of interest was to vary the ACR minimum flow rate for detachment. The study was performed using a switchback design. The first herd varied the ACR minimum flow rates between 1.1 (L = Low) and 1.4 (H = High) lbs per minute, completing the switchback treatment twice (L:H:L:H) for a total of four treatment periods. The four remaining herds varied ACR minimum flow rates between 1.6 (L) and 1.8 (H) lbs per minute between alternating treatment periods. Two of these herds completed the switchback treatment twice (H:L:H:L or L:H:L:H) for a total of four treatment periods, while the remaining two herds completed the switchback treatment once (H:L or L:H) for a total of two treatment periods.

***Data Analysis*.** Data were analyzed for each herd and milking to describe average milking duration (min/cow) and average milk yield (lbs/cow). The analysis was performed using least squares ANOVA using GLM and Mixed procedures in SAS (version 8.0, 2000). Two distinct models were created using the combined data from the second, third, fourth, and fifth herds to describe the effect of ACR treatment (1.6 vs. 1.8 lbs per min) on the two dependent variables of interest: duration (min/cow) and milk yield (lbs/cow). Fixed effects in each of these five models included herd, treatment period (1, 2, 3 or 4), milking period (am, mid-day, or pm), ACR treatment setting (1.6 or 1.8 lbs/min), and a residual error term. An additional term, milk yield per cow (lbs/cow) was also offered into the model describing the association between ACR treatment and duration, to control for the potential confounding effects of changes in milk production during the study period on the relationship between ACR treatment and duration. Non-significant variables were eliminated by a backwards elimination process. Least squares means and the standard error of the means were calculated for both outcome measures.

Two two-way interaction terms, between treatment and herd, and between treatment and period, were also offered to each model. If significant interactions between treatment and either herd or period were detected then stratified analysis was performed. Statistical significance was declared at $P < 0.05$. The data from the first herd was omitted from this initial combined-herd analysis due to the fact that both the absolute levels and the magnitude of difference between the ACR settings were different in this herd (ACR at 1.1 vs 1.4 lbs/min) as compared to the other four herds (ACR at 1.6 vs. 1.8 lbs per min). However, data from all five herds were analyzed and reported when stratified analysis was performed.

Results

The five study herds milked an average of 728 cows (S.D. = 308; range = 428 to 1344) at any given milking during the study period. Mean milking duration was 5.14 min/cow (S.D. = 0.53, range = 4.1 to 6.8). Milk production averaged 28.3 lbs/cow/milking (S.D. = 3.9; range = 17.8 to 36.2). Herds spent an average of 21 milkings in a given treatment period at a single ACR setting (S.D. = 8.3; range = 7 to 31). A description of the raw (unadjusted) data for each herd and for each ACR treatment is provided in Table 1.

Yield per minute (lbs/min) was calculated by dividing production of each cow by her duration at each milking. Mean yield per minute was 5.63 lbs/min (S.D. = 0.53, range = 4.0 to 6.6). While not an objective of this study, ANOVA showed that mean yield per minute was significantly higher ($P < 0.05$) at the higher ACR settings for all five study herds (Table 1).

Multivariate combined-herd analysis showed that, while the ACR treatment was associated with a reduced milking duration ($P < 0.05$), there was a strong tendency for a treatment*herd interaction effect ($P = 0.064$). Subsequent analysis after stratification by herd showed that increasing the ACR minimum flow rate was associated with a significant reduction in milking duration in four of the five herds ($P < 0.05$). In herds 1, 3, 4, and 5, the estimated net decrease in milking duration ranged between 0.17 and 0.26 min/cow (10.2 to 15.6 seconds/cow) (Table 2). There was no association between ACR treatment and duration for herd 2 ($P > 0.05$).

Multivariate combined-herd analysis showed a strong tendency for ACR treatment to have a positive effect on the amount of milk harvested/cow ($P = 0.063$). Subsequent analysis after stratification of data by herd showed that increasing the ACR minimum flow rate was associated with a significant increase in milk harvested/cow in the first two herds ($P < 0.05$) (Table 2). However there was no association between ACR treatment and milk harvested/cow in the remaining three herds (Table 2) ($P > 0.05$).

Discussion

Previous studies of the relationship between ACR minimum flow rate settings and measures of parlor efficiency have been limited to either case reports describing field observations in individual herds or individual animals managed in a research environment.[11 - 13] The current study is the first formal study of its kind performed in multiple commercial dairy herds and under field conditions. The results of the current field study, while varying among herds, were generally consistent with the findings of these previous reports. For four of the five herds we observed an estimated net decrease in milking duration ranging between 10.2 and 15.6 seconds with either a gain or, at least, no reduction, in milk yield.

Ultimately, we would expect that reducing the average milking duration per cow would result in an improvement in the efficiency of parlor performance as measured by increased number of turns per hour. However an increase in turns per hour was not observed in the current study. This was likely a reflection of the relatively small incremental differences between ACR settings studied, but could also have been due to the existence of other unmeasured management-related bottlenecks to improving parlor performance. Opportunities for greater magnitudes of change in ACR settings and subsequently, more dramatic improvements in parlor efficiency exist in many commercial dairies where such fine-tuning of milking procedures and equipment has not already occurred. An example of this was described in a case study of a 430-cow dairy milking 3X wherein the gradual shortening of the ACR delay time from 12 to 3 seconds and gradually increasing the ACR minimum flow rate from 0.7 to 1.3 lbs/min resulted in a reduction in average unit on-time from 7.8 minutes to 6.4 minutes and a reduction in milking time of 30 to 60 minutes per milking for the entire herd, with milk production staying between 85 and 87 lbs/cow/day.[12] These time savings allowed this particular herd to easily milk at least 70 more cows with the same labor costs that were needed to previously milk 430 cows.

In this field study producer compliance in changing the ACR settings on scheduled days was not always perfect. As a result, the number of milkings spent at high and low ACR settings were not always equal in this study. However, this was not of great concern since the Mixed and GLM procedures can deal with unbalanced data. A second potential concern in a field study of this nature is whether changes in average days in milk, as cows are dried off or freshened into the milking herd, could influence some of the dependent variables of interest, such as milk production, and so confound the study findings. However, given the very short period that a herd was on any given treatment level, given the stable herd sizes, and considering the herd sizes involved, the average days in milk did not change very much. Additionally, the models controlled for milk production when examining the effects of ACR levels on the outcome of milking duration. Finally, the short periods of time on individual ACR treatment levels and the switchback study design should have helped to control for potential confounding introduced by some other changes that could have occurred over the one-month period of the study (e.g. sudden climate changes or changes in parlor labor).

In the current study, average yields per minute were shown to increase at the higher ACR minimum flow rate settings. This result was expected if total milk yield remained constant because such adjustments would result in the milking units being removed earlier. Yield per minute can also be referred to as average flow rate, but this terminology should not be interpreted that the instantaneous flow rate of any cow was altered at any point.

While milking duration was the primary outcome of interest, any reduction of milk yield would have been viewed as negative. The amount of milk harvested was not reduced at the higher ACR settings used in this study. However, it cannot be concluded that the trend for increased milk production was caused directly by the higher ACR settings. In addition to improving milking efficiency, higher ACR minimum flow rate settings could result in less overmilking in some herds. While teat end condition and udder health were not outcomes of interest in the current study, the prevention of overmilking could also lead to better teat end condition and potentially to improved udder health.[2 - 10, 14]

Conclusions

An electronic parlor data capture system was used successfully to investigate the effects of various planned changes to system ACR settings on milking efficiency and parlor performance. While increasing the ACR minimum flow rate was not associated with average milking duration per cow in one herd, it had the effect of significantly reducing the average milking duration between 10.2 and 15.6 seconds per cow in the remaining four herds. Higher ACR settings did not have a negative effect on milk yield in any of the herds studied and, in fact, were associated with increased milk yield in two of the five herds.

In four of the five herds studied, increasing the ACR minimum flow rate did have a positive effect on variables that should ultimately lead to improved milking efficiency and parlor performance (i.e. decreased milking duration with no change or increased volume of milk harvested). One caution is that ACR adjustments only be made in herds with good udder preparation procedures and well-maintained equipment.[13] Such adjustments should be made in small, gradual increments, and the responses carefully monitored.

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Table 1. **Unadjusted data describing herd average parlor performance per milking at two different takeoff settings**

Variable	Herd 1 (1100)		Herd 2 (0110)		Herd 3 (0027)		Herd 4 (0055)		Herd 5 (0167)	
Milkings/day	3X		2.5X		3X		3X		3X	
Parlor size	Double 12		Double 24		Double 10		Double 12		Double 12	
Switchback direction	L:H:L:H *		H:L:H:L *		L:H *		H:L *		L:H:L:H *	
ACR (lbs/min)[1]	**1.1**	**1.4**	**1.6**	**1.8**	**1.6**	**1.8**	**1.6**	**1.8**	**1.6**	**1.8**
Total milkings	50	42	49	20	30	30	28	10	38	32
Avg. #r cows	490	492	1303	1305	654	648	462	461	682	680
Avg. lbs/min	4.88	5.26	6.10	6.21	5.35	5.53	5.65	5.83	5.83	6.24
Avg duration(min)	5.04	4.84	5.59	5.68	5.23	5.05	5.86	5.78	4.62	4.40
Avgmilk/cow(lbs)	24.65	25.31	32.95	33.87	27.55	27.47	31.01	31.47	26.96	27.26

[1] ACR = Automatic takeoff minimum flow rate setting (lbs/min)
* L = low ACR minimum flow rate setting (1.1 or 1.6 lbs/min)
* H = high ACR minimum flow rate setting (1.4 or 1.8 lbs/min)

Table 2. **Least squares means and statistical significance from stratified analysis of the effect of automatic takeoff settings on milking duration (min/cow) and milk yield (lbs/cow).**

Outcome Variable	Herd	ACR Setting [1]	LS Mean	LS Stand. Error	Difference	P Value	Model r^2
Duration[1] (min/cow)	1	1.1	5.07	0.019	0.26	< 0.0001	0.90
		1.4	4.81	0.021	(15.6 sec)		
	2	1.6	5.62	0.016	-0.0073	0.81	0.61
		1.8	5.62	0.025	(0.4 sec)		
	3	1.6	5.23	0.018	0.18	< 0.0001	0.67
		1.8	5.05	0.018	(10.8 sec)		
	4	1.6	5.89	0.031	0.17	0.0073	0.88
		1.8	5.72	0.051	(10.2 sec)		
	5	1.6	4.63	0.011	0.24	< 0.001	0.85
		1.8	4.39	0.012	(14.4 sec)		
Milk[2] (lbs/cow)	1	1.1	24.62	0.16	-0.69	0.0047	0.90
		1.4	25.31	0.17			
	2	1.6	32.84	0.16	-0.90	0.003	0.36
		1.8	33.74	0.25			
	3	1.6	27.55	0.22	0.077	0.81	0.20
		1.8	27.47	0.22			
	4	1.6	30.91	0.27	-0.28	0.60	0.71
		1.8	31.19	0.45			
	5	1.6	26.86	0.20	-0.36	0.22	0.43
		1.8	27.23	0.22			

1 Herd-stratified models control for milking time (am, mid-day, pm) and milk production (lbs/cow) for each milking event.

2 Herd-stratified models controlled for milking time (am, mid-day, pm).